[1]National Research Tomsk Polytechnic University

[2]Tomsk State Pedagogical University

Neutrons planar channeling in the crystals

K.B. Korotchenko[1], Yu.P. Kunashenko[1,2]
Yu.L. Pivovarov[1]

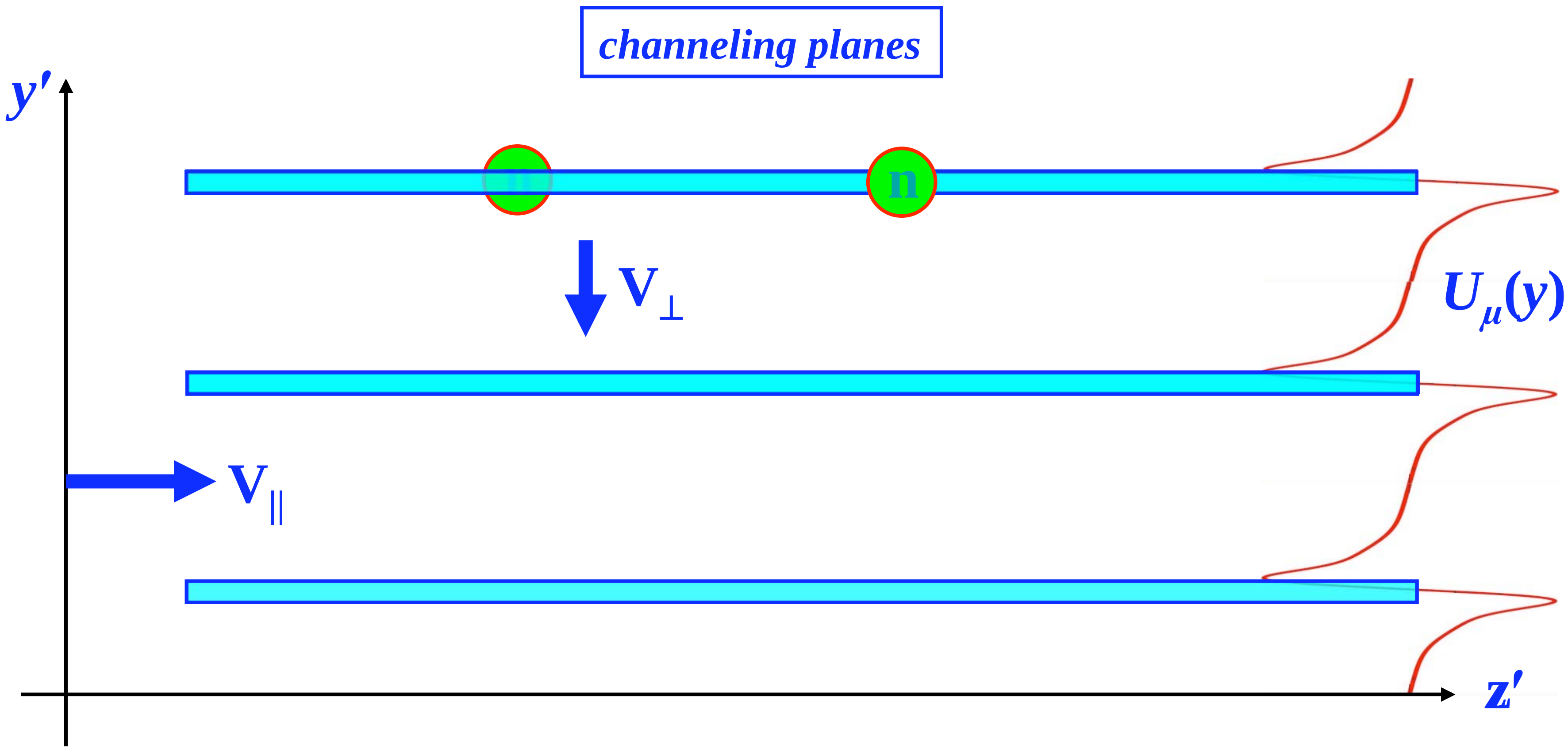
The electromagnetic (Schwinger) scattering of fast neutrons in aligned crystals was considered in works [1-6].

1. A.N.Dyumin, I. Ya. Korenblit, V.A. Ruban, B.B. Tokarev, Pis'ma v ZhETP **31** (1980) 413.
2. V.G.Baryshevskii, A.M. Zaitzeva, Izv. VUZov **3** (1985) 103.
3. A.N.Dyumin, V.A. Ruban, B.B. Tokarev, M.F. Vlasov, Pis'ma v ZhETP **42** (1985) 61.
4. Yu.P.Kunashenko, Yu.L.Pivovarov, Charged and Neutral Particles Channeling Phenomena (Channeling 2008): Proceedings of the 51st Workshop of the INFN Eloisatron Project - Erice, Italy, October 25 – November 1, 2008. - Erice: World Scientific (2010) 794.
5. Yu.P.Kunashenko, Yu.L.Pivovarov, Book of Abstract of XL International conference on Physics of Interaction of Charged Particles with Crystals. Moscow, May 25-27 Moscow State University (2010) 56.
6. V.I. Visotskii and M.V. Visotskyy // J. Surface Investigation. X-Ray, Synchrotron and Neutron Techniques 4 (2010) 100.

Neutron channeling model

channeling planes

Neutron channeling model



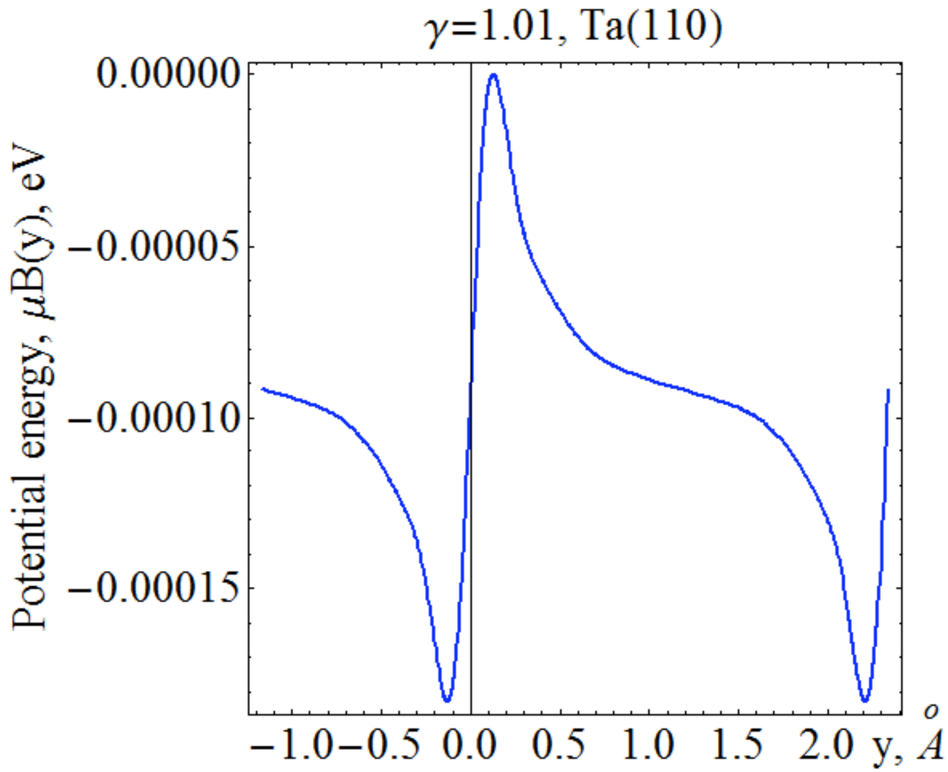
$V_{\parallel} \gg V_{\perp}$

$$\Phi_i''(y) + \frac{\hbar^2}{2m_n\gamma}(\varepsilon_i - U_\mu(y))\Phi_i(y) = 0$$

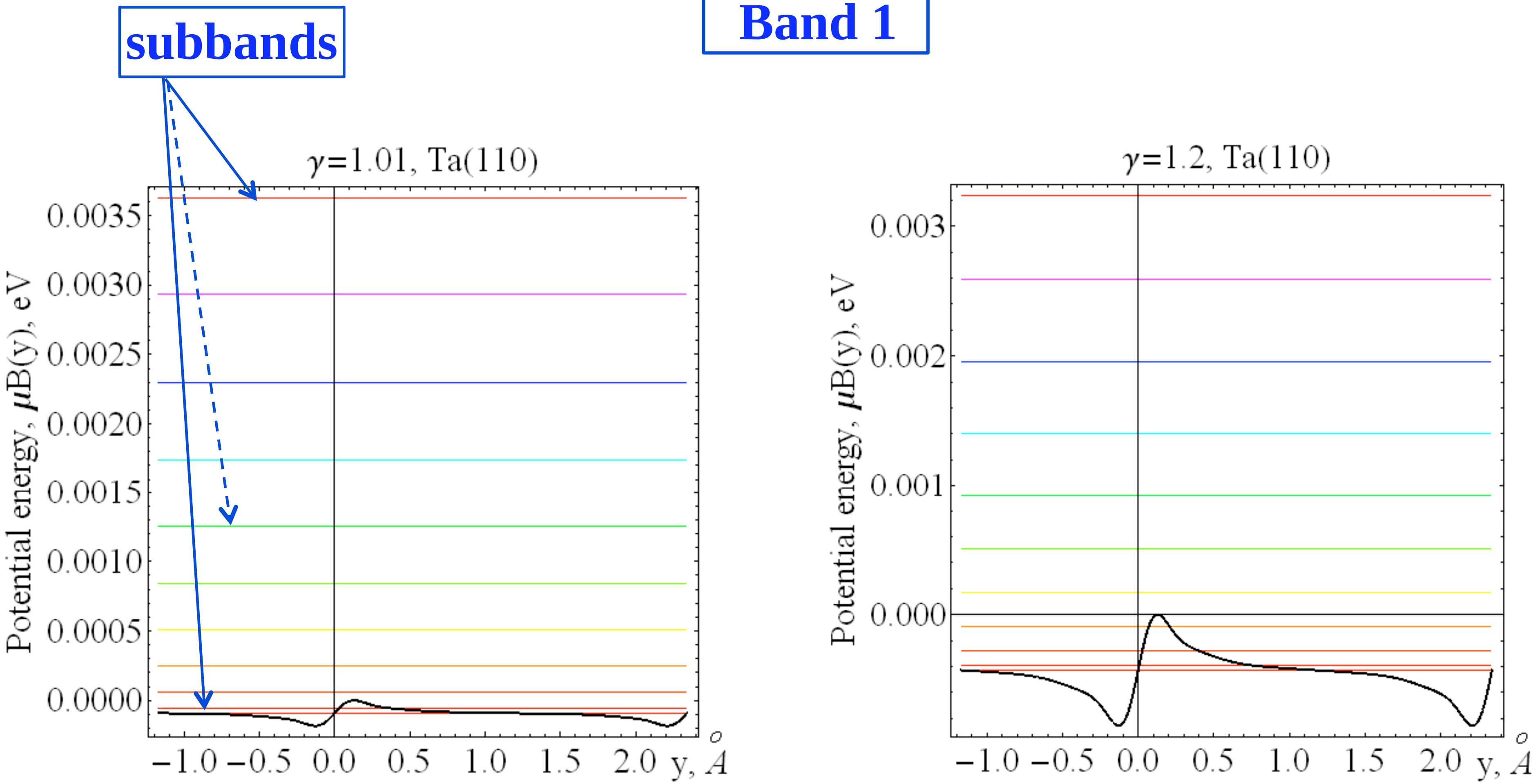
$$U_\mu(y) = \vec{\mu}\vec{B}(y)$$

$$\vec{B}(y) = \sqrt{\gamma^2 - 1}\left[\vec{v}_\parallel, \vec{E}(y)\right]$$

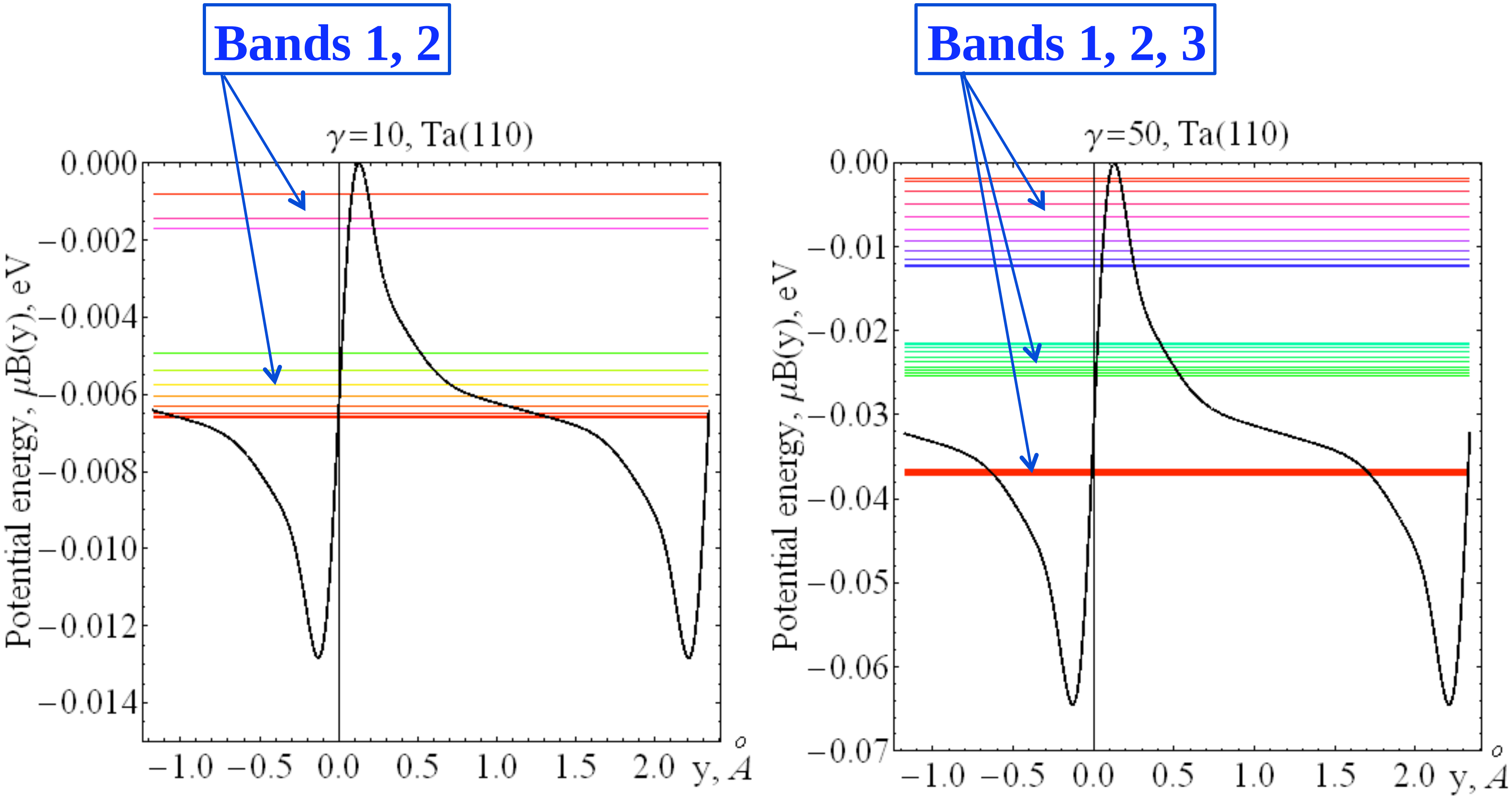
$$\vec{E}(y) = -\nabla U_{Ta}(y)$$



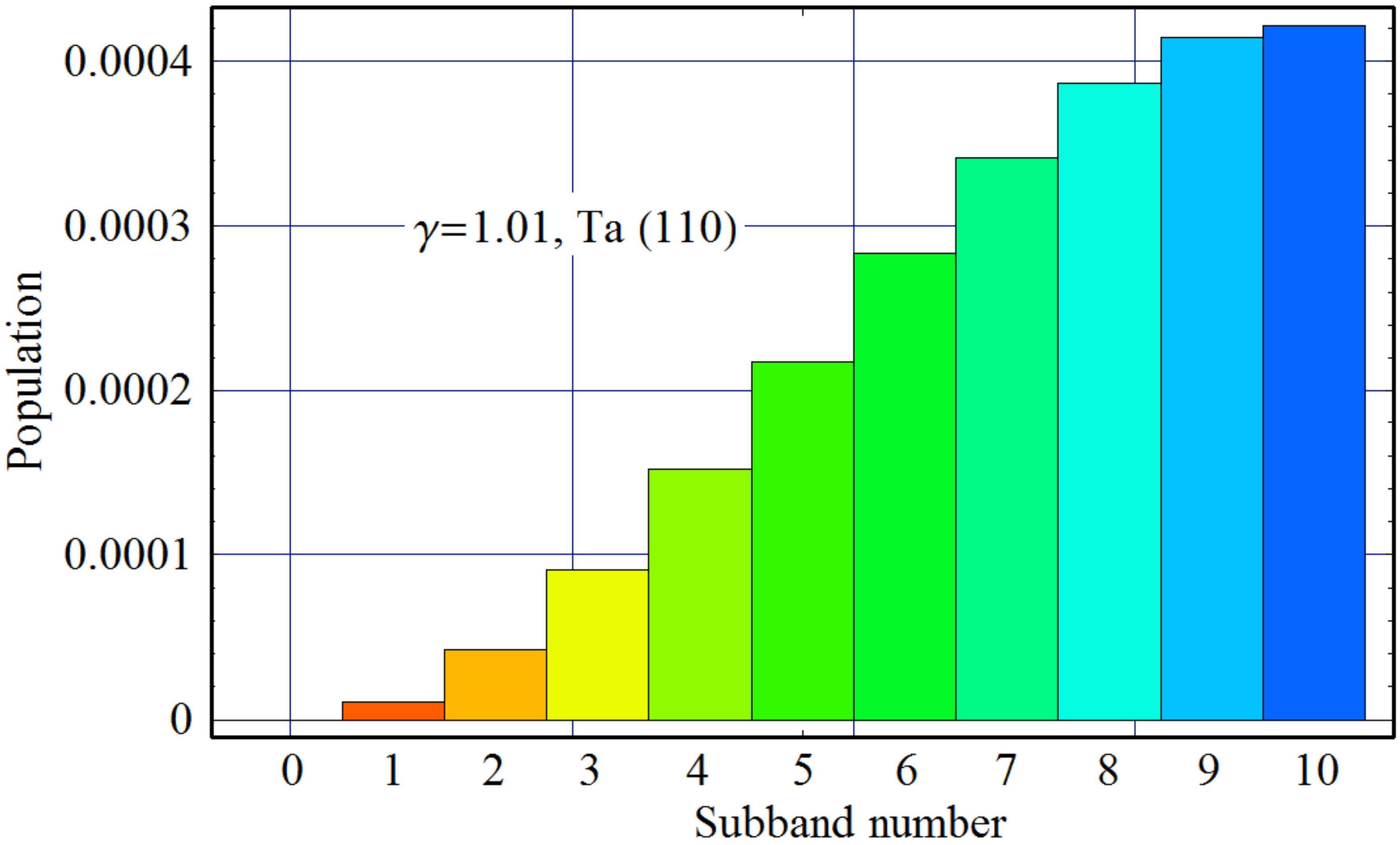
Band 1



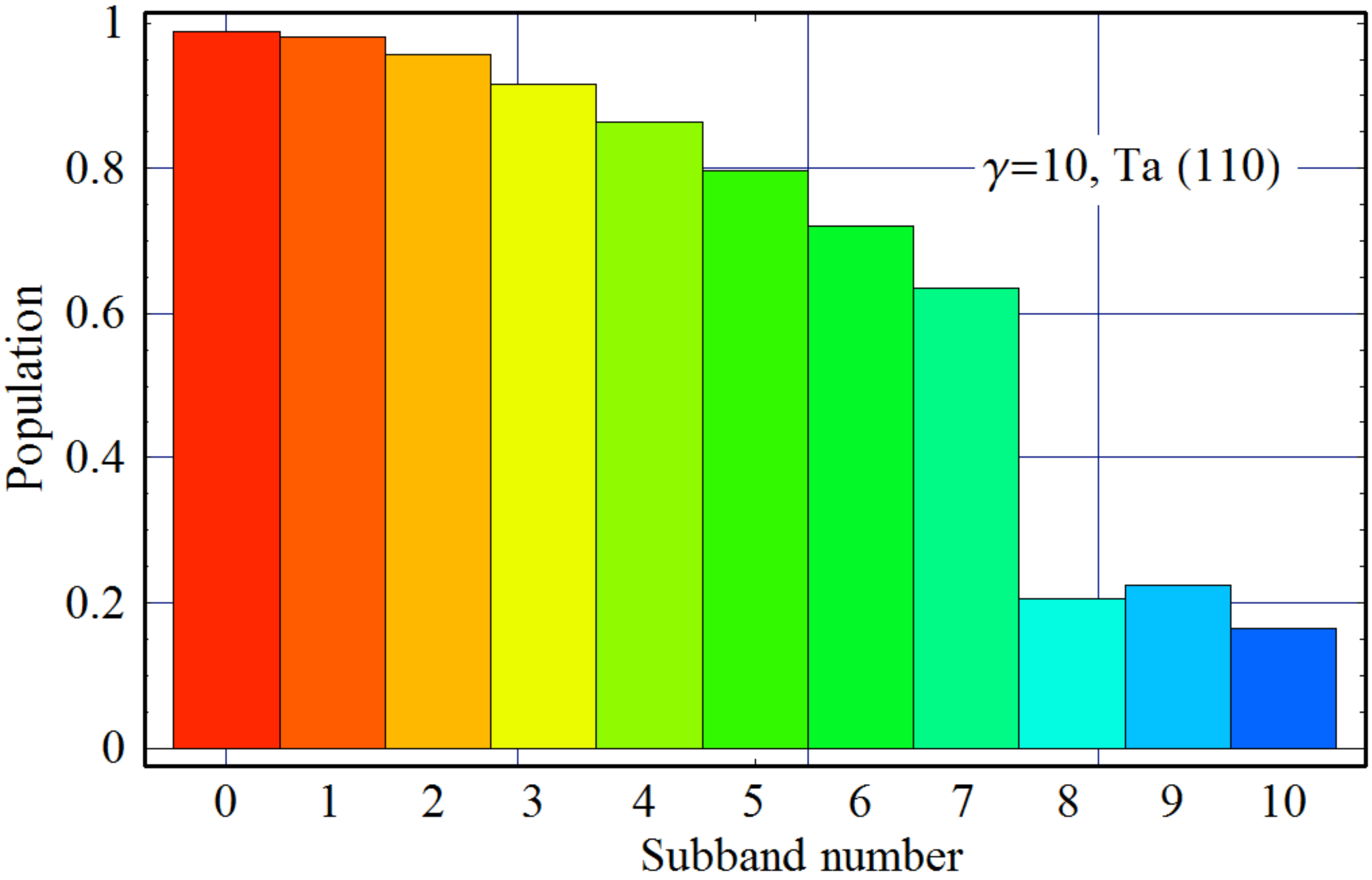
$\theta_0 = 0$


Bands 1, 2
γ=10, Ta(110)
Potential energy, μB(y), eV
y, Å
Bands 1, 2, 3
γ=50, Ta(110)
Potential energy, μB(y), eV
y, Å

$\theta_o = 0$



γ=1.01, Ta (110)
Population
0.0004
0.0003
0.0002
0.0001
0
0
1
2
3
4
5
6
7
8
9
10
Subband number



γ=10, Ta (110)
Population
0
0.2
0.4
0.6
0.8
1
0
1
2
3
4
5
6
7
8
9
10
Subband number

$$\vec{E}(y) = -\nabla U_{Ta}(y) \qquad U_{\mu}(y,\gamma) = |\mu| B(y,\gamma)$$

$$\vec{B}(y,\gamma) = \sqrt{\gamma^2 - 1}\left[\vec{v}_{\parallel}, \vec{E}(y)\right]$$

μ - **anomalous magnetic moment of neutron**

$$\sigma_{ij} = \begin{pmatrix} 0 & 0 & 0 & 0 \\ 0 & 0 & -\sigma_z & \sigma_y \\ 0 & \sigma_z & 0 & \sigma_x \\ 0 & -\sigma_y & \sigma_x & 0 \end{pmatrix} \qquad F_{ij} = \begin{pmatrix} 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & B(y,\gamma) \\ 0 & 0 & 0 & 0 \\ 0 & -B(y,\gamma) & 0 & 0 \end{pmatrix}$$

spin tensor of neutron **field tensor**

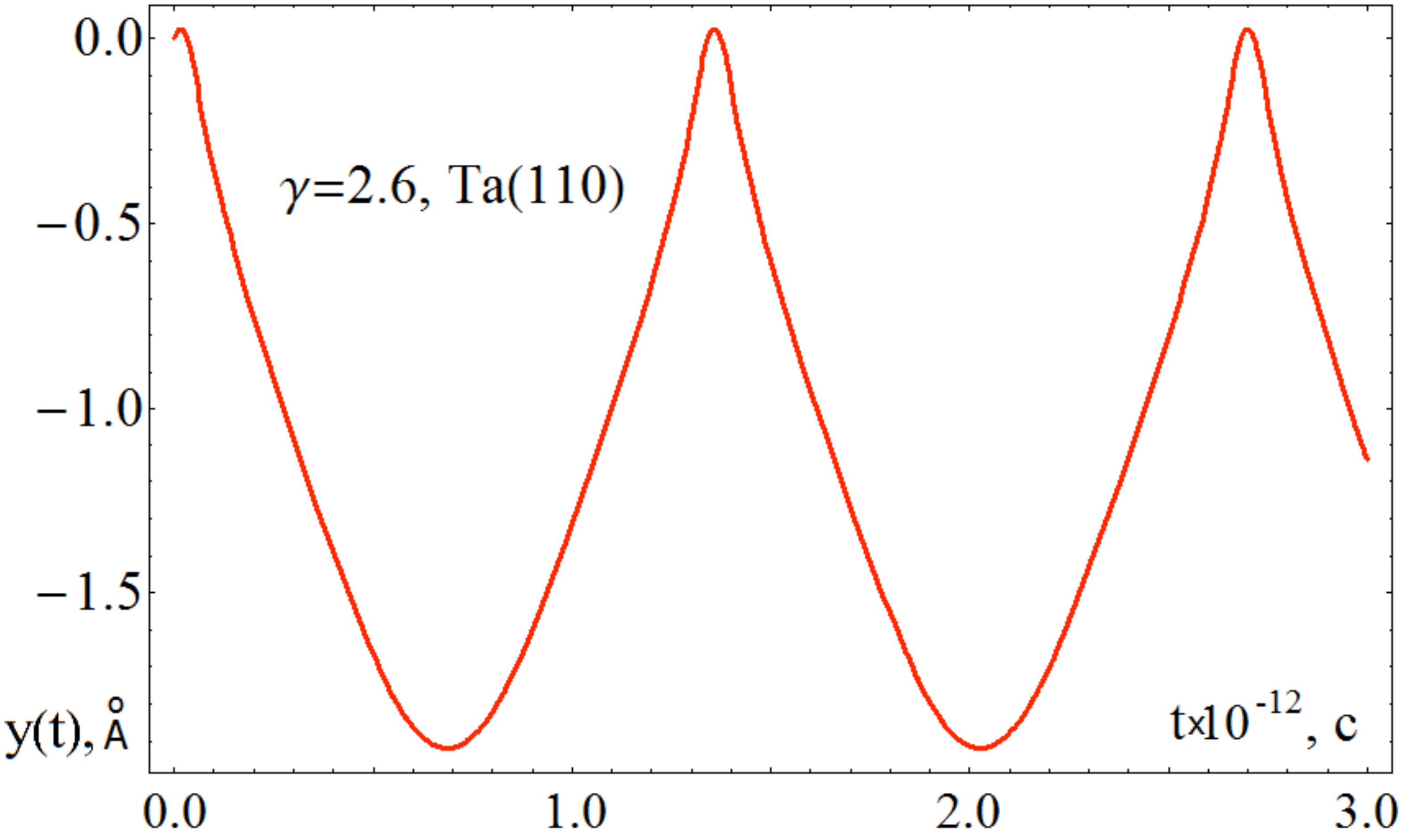
BMT[1]

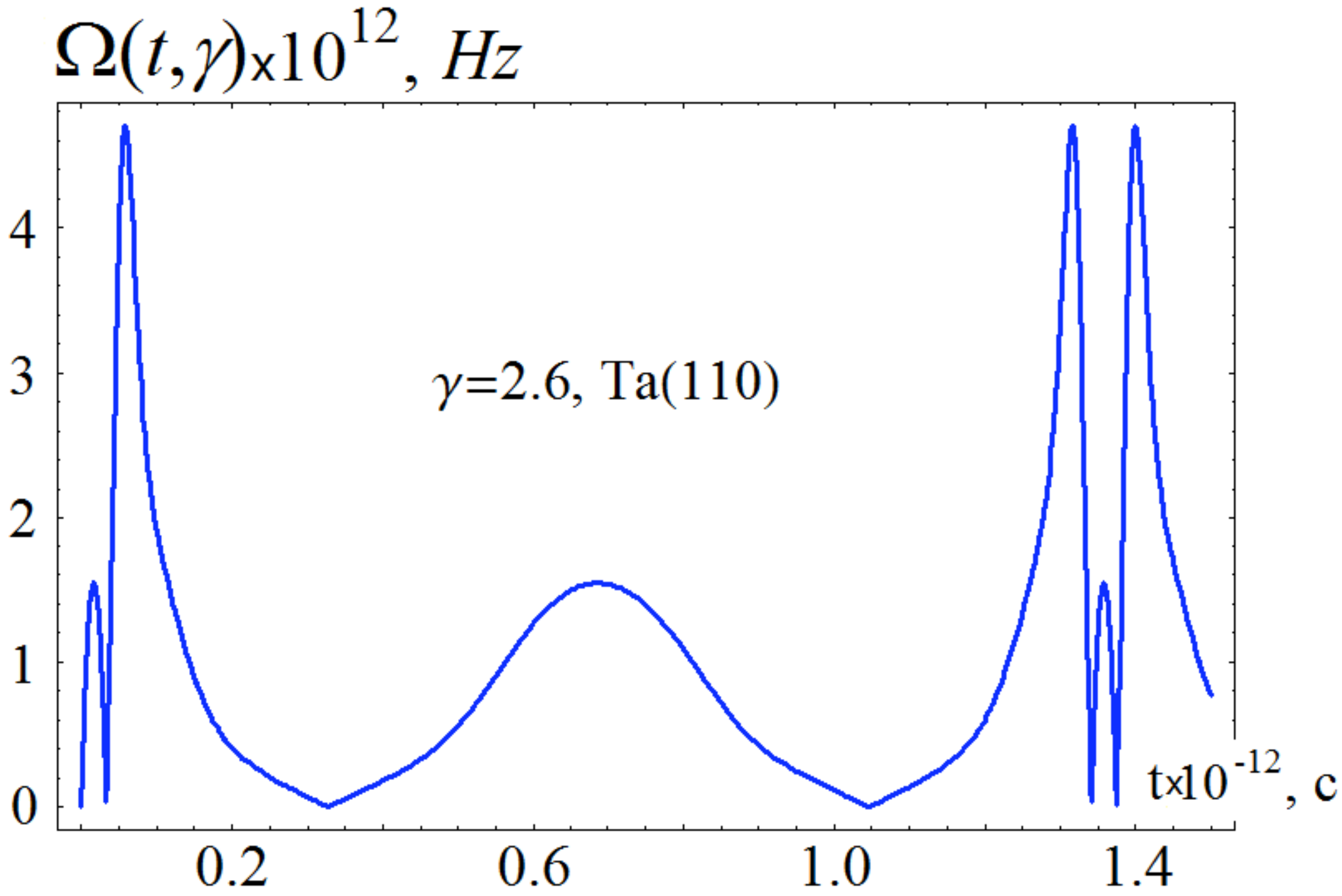
$$
\begin{cases}
\ddot{y}(t) = \sigma_x \partial_y U_\mu(y,\gamma), \\
\ddot{\sigma}_y(t) + \Omega^2(t,\gamma)\sigma_y(t) = F(t,\gamma)\dot{\sigma}_y(t)
\end{cases}
$$

$$
F(t,\gamma) = \frac{\dot{y}(t) + \partial_y U_\mu(y(t),\gamma)}{U_\mu(y(t),\gamma)}, \quad \Omega(t,\gamma) = \frac{2U_\mu(y(t),\gamma)}{\hbar}
$$

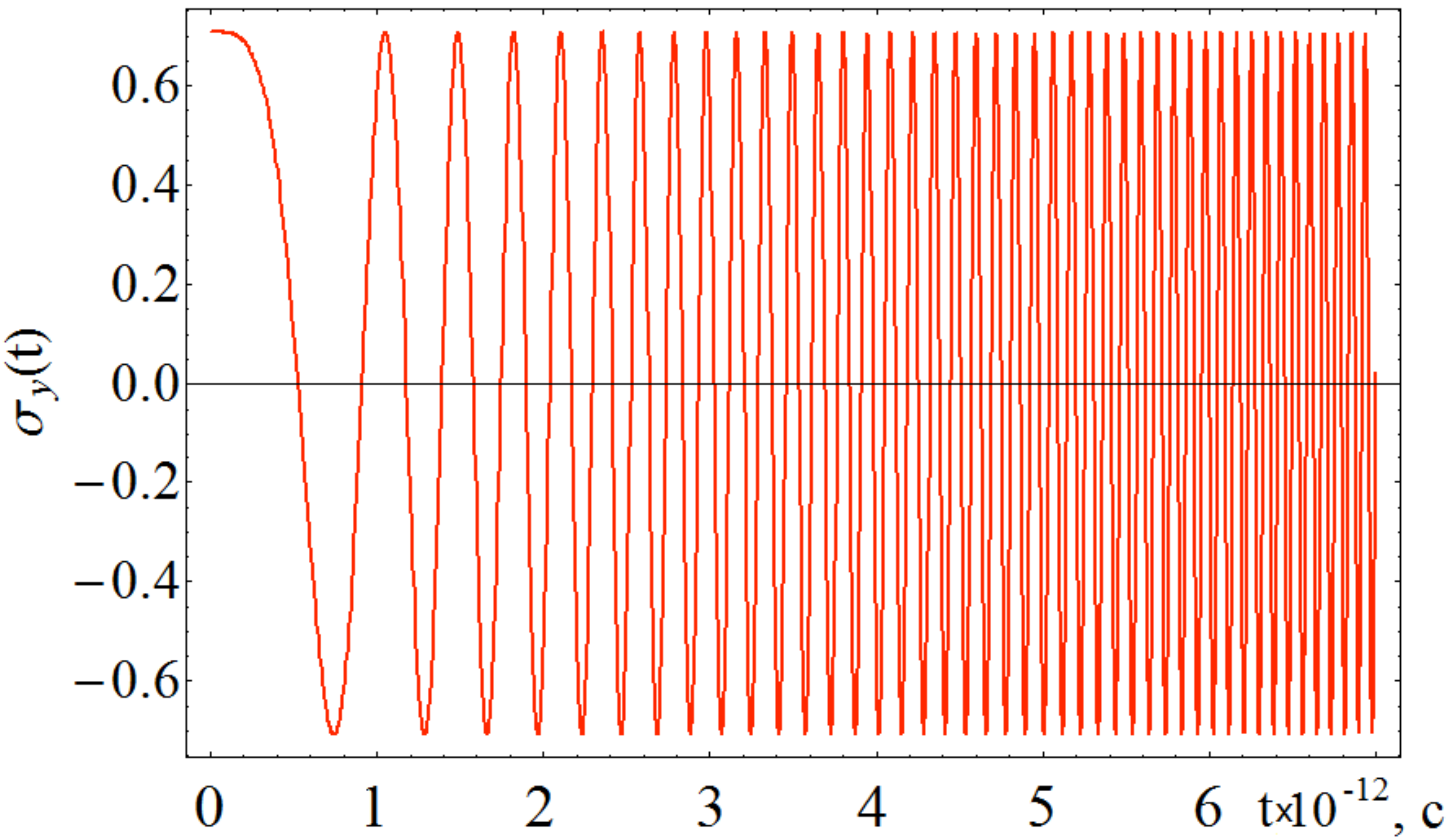
$$
\sigma_z(t) = -\hbar\dot{\sigma}_y(t) \big/ 2U_\mu(y(t),\gamma)
$$

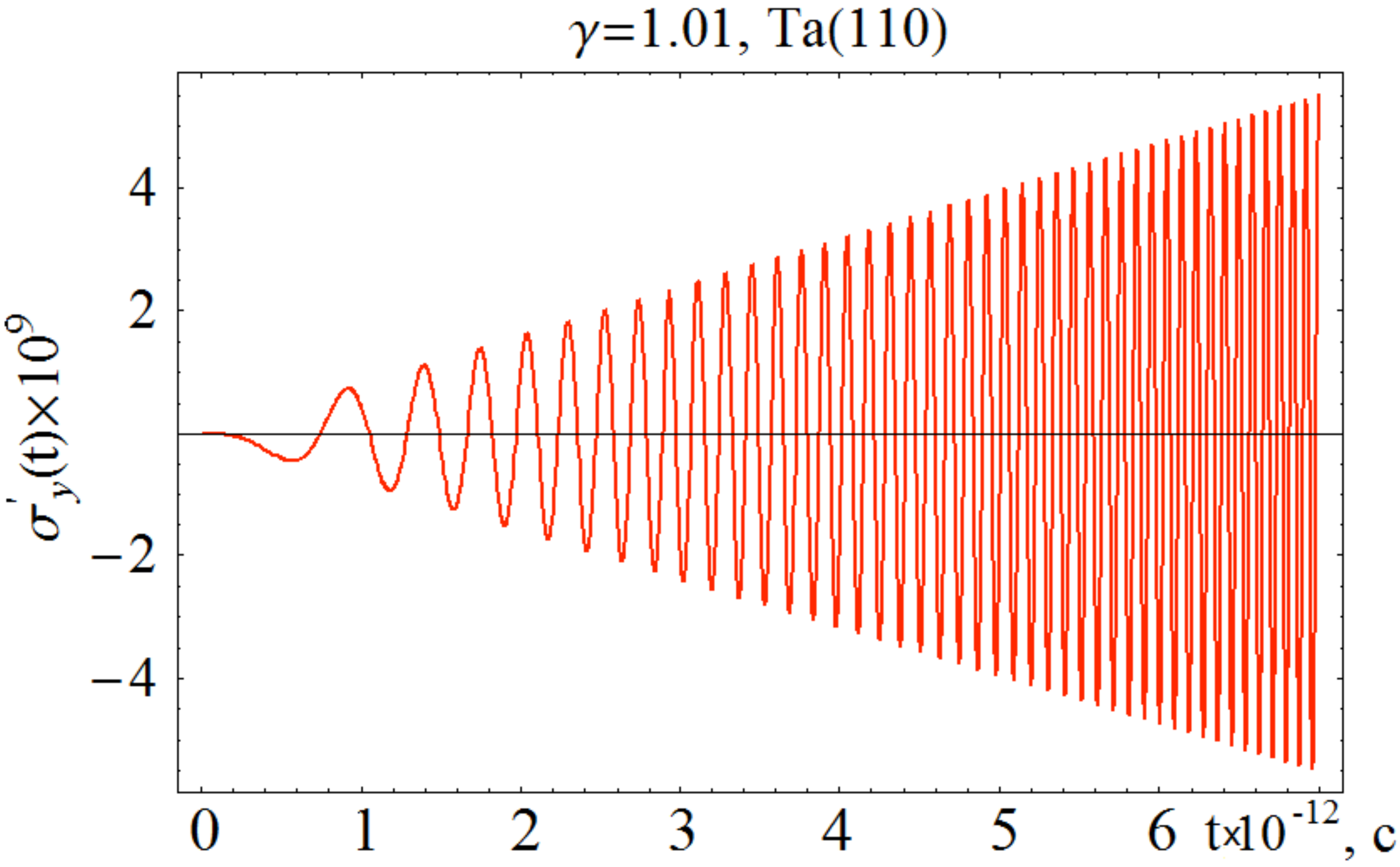
1. *I.M. Ternov, V.A. Bordovitsyn* // Usp. Fiz. Nauk 132, No. 2, 345 (1980).


γ=2.6, Ta(110)
y(t), Å
t×10^-12, c
0.0
−0.5
−1.0
−1.5
0.0
1.0
2.0
3.0

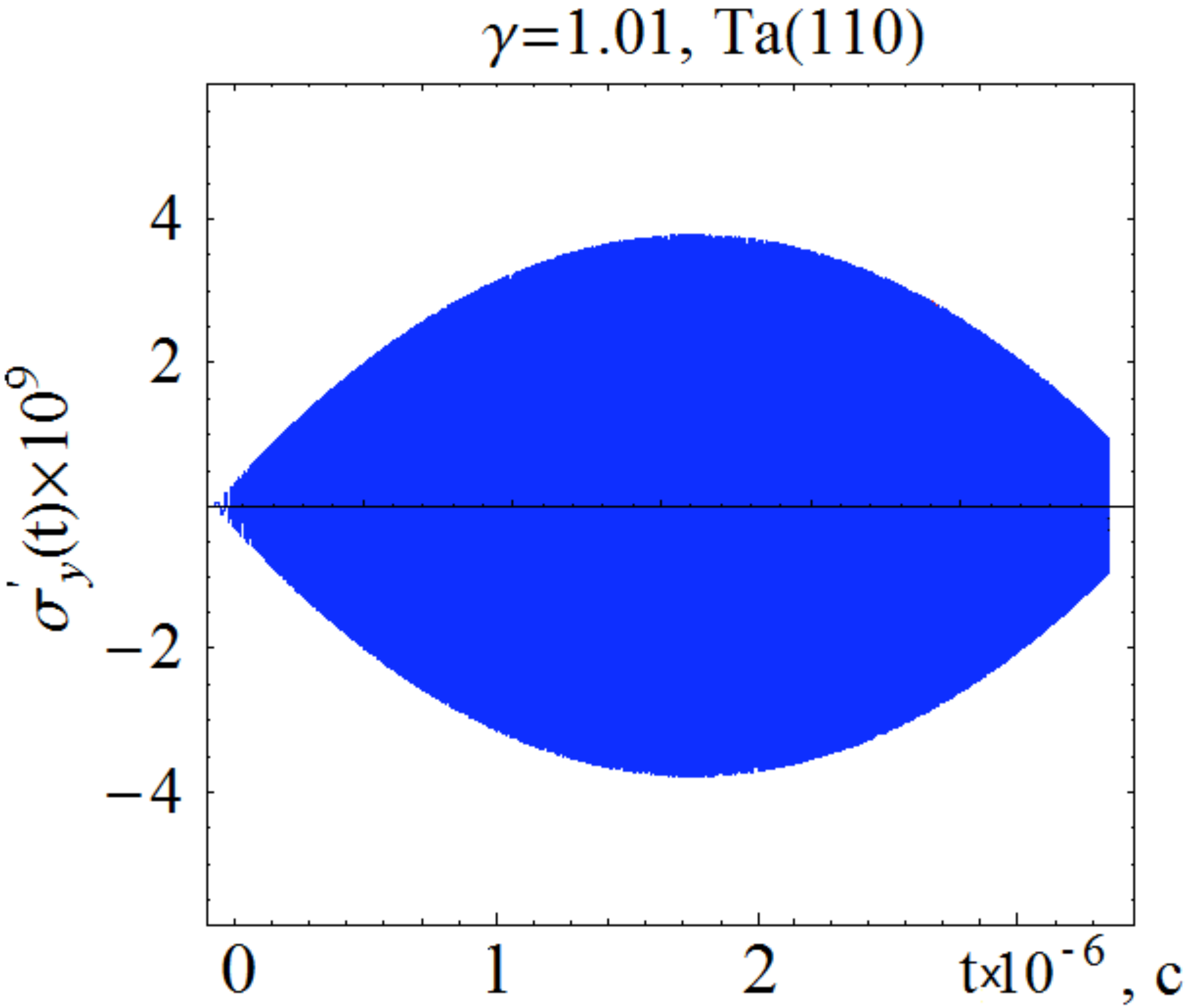

Ω(t,γ)x10^12, Hz
4
3
2
1
0
γ=2.6, Ta(110)
tx10^-12, c
0.2
0.6
1.0
1.4

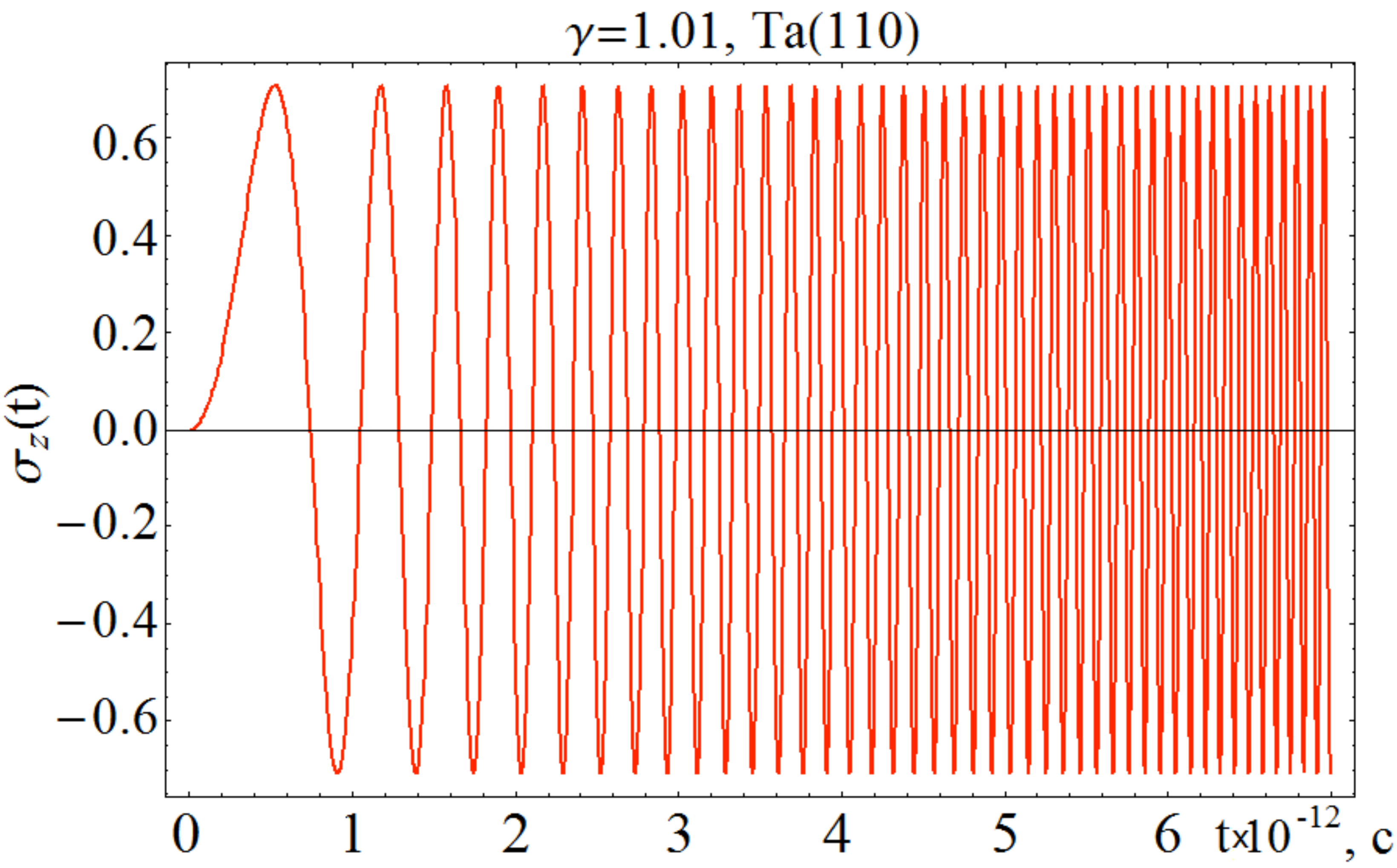
γ=1.01, Ta(110)





γ=1.01, Ta(110)
$\sigma'_y(t)\times10^9$
4
2
−2
−4
0
1
2
3
4
5
6
t×10^{-12}, c


γ=1.01, Ta(110)
σ'y(t)×10^9
4
2
−2
−4
0
1
2
t×10^-6, c


γ=1.01, Ta(110)
0.6
0.4
0.2
0.0
−0.2
−0.4
−0.6
σ_z(t)
0
1
2
3
4
5
6
t×10^-12, c

The work is partially supported by Russian Science and Innovations Federal Agency under contract No 02.740.11.0238, Russian Fund for Basic Research under grant No 10–02–01386–a, Foundation of Supporting of Scientific Schools under contract No 3558.2010.2

Thanks for attention